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RESEARCHES ON THE ANATOMY OF AMPHISTOMUM FABACEUM DIESING.

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Introduction.

The worms which formed the material for this research were taken from the large intestine of a manatee (Manatus, or Trichechus Americanus) which was received from Brazil by the Anatomical Department of the Cornell University, October 27th, 1885. On removal from the body they were immediately placed in Müller's fluid, and subsequently sent to the Entomological Department, where the process of hardening was completed by placing them in increasing strengths of alcohol.

In order to make a most complete and detailed study of their anatomy, part of the worms should have been injected, a few mascerated, and others made transparent by different processes. But as I had no thought at that time of making a complete study of their anatomy, all the worms were hardened and preserved in alcohol. It therefore became necessary in this research to make my observations by means of serial sections. Several worms were, however, rendered sufficiently transparent to enable me to study their gross anatomy by prolonged soaking in glycerine. Overstaining, decolorizing, clearing, and mounting in balsam did not give satisfactory results.

Several complete sets of very carefully prepared and arranged serial sections were made in the three body planes. The sections were all made by the paraffine method and fastened to the slide with clove-oil collodion. Most of them were double-stained with haematoxylin and fluorescine, others with alum-carmine, and a few with picro-carmine. The tissues were very slow to the action of the stain, especially alum-carmine, although the hardening agent was thoroughly removed before infiltration and the sections left in the alcohol from twelve to twenty-four hours before applying the stain.

The outlines, relation of parts, and general structure of most of the illustrations were taken from photo-micrographs by the use of tracing paper, while the details were put in by the unaided eye direct from the object under the microscope.

General Description.

This species varies in color from a light brown to a light yellow. It is of a discoidal oval form, rather more pointed cephalad than caudad, with the ventral surface flat or slightly concave, and the dorsal surface convex (Plate 1, Figs. 1, 2, 3, 4; Plate 2, Figs. 1, 4, 5). It measures from 9 to 10 millimeters in length, 5 mm. in width and 2 mm. in thickness (Plate 1, Figs. 1, 2).

On the ventral surface of the cephalic extremity is the *buccal sucker* (Plate 2, Fig. 1 s.); this is of an oval form and pierced by an orifice, the mouth (Plate 1, Figs. 3, 4 a; Plate 2, Figs. 1, 3 a). Also on the ventral surface near the caudal extremity of the body is another sucker (Plate 1, Figs. 3, 4 f; Plate 2, Fig. 1 j, Fig. 3 t) of a circular form, and of about five times the diameter of the buccal sucker, but which is not pierced by an orifice, and is known as the *ventral sucker.*

Between the two suckers, at about one-third the length of the worm from the mouth, is situated the external opening (Plate 1, Figs. 3, 4 d; Plate 2, Figs. 1, 5 h) of the reproductive organs, both male and female.

On the dorsal surface at about two-thirds the length of the animal from the mouth is situated the opening of the excretory system (Plate 1, Figs. 3, 4 g; Plate 2, Fig. 1 k).

The general course of the alimentary canal can be easily seen in specimens rendered transparent by soaking in glycerine. It appears as a dark band extending in a straight line from the mouth to about one-third the length of the body, where it divides into two branches (Plate 1, Figs. 3, 4 e; Plate 2, Fig. 3 s), which immediately diverge and pass caudad to the ventral sucker on each side of which they end.

Special Anatomy.

The body of an Amphistomum is composed of two grand and distinct divisions or parts, which become visible upon the examination of a section of the animal: the first is the dense, tough, and comparatively thick skin or *tegument* which forms the body wall and surrounds the entire animal (Plate 2, Fig. 1 v, Figs. 3, 4, 5 o); the second has a soft, spongy appearance and is known as the *parenchyma* (Plate 1, Fig. 10; Plate 2, Figs. 1, 3, 4, 5); it fills the entire animal, and in it are imbedded the principal organs.

The Tegument.

The Cuticle.—This forms the external covering to the entire animal (Plate 1, Figs. 9 b, 10 s). It is a thin chitinous layer $3\frac{1}{2}$ μ in thickness, and is entirely devoid of structure. Its external surface bears numerous appendages in the form of slender cones or spines (Plate 1, Fig. 9 a), which are directed a little caudad, and are far more numerous and larger on the dorsal surface where they attain the length of $8\frac{3}{4}$ μ. The cuticle may be separated as a thin membrane from the tissue beneath it by masceration for some hours in water containing a few drops of ammonia.

The Matrix.—Immediately below the cuticle is a layer of opaque, viscous, and granular intercellular substance (Plate 1, Fig. 9 c), without structure (I was unable to find nuclei there), constituting a matrix for the cuticle, and continuing throughout the remainder of the tegument (Plate 1, Fig. 9), forming a cement which fastens and holds together the different layers of muscular fibres and the cells beneath. I was unable to detect the presence of cells forming a true matrix in this substance just beneath the cuticle.

The Dermo Muscles.—Almost immediately beneath the cuticle, but separated by the thin layer of intercellular substance mentioned above, we find five distinct coats or layers of muscular fibres, constituting the greater part of the tegument of the animal, and giving to it its firm consistence (Plate 1, Fig. 9 d, e, f, g, h; Fig. 10 a, b, c, d).

Starting with the outermost layer and working entad, we find: First, a layer of transverse muscular fibres (Plate 1, Fig. 5 a; Fig. 9 d) which extend around the animal like hoops around a barrel;

second, a layer of longitudinal muscular fibres (Plate 1, Fig. 5 b; Fig. 9 e) running at right angles to the first; third, a layer, the fibres of which have a diagonal direction (Plate 1, Fig. 5 c; Fig. 9 f) and extend from the left (dextral) caudad to the right (sinistral) side; fourth, another diagonal layer (Plate 1, Fig. 5 d; Fig. 9 g) with the fibres running in the other direction, that is, from the right (sinistral) caudad to the left (dextral) side, and at nearly right angles to those of the third layer; fifth, and last, a layer of longitudinal muscular fibres (Plate 1, Fig. 5 e; Fig. 9 h) having a direction parallel to those of the second layer.

Each distinct muscular coat is composed of a single layer of muscular fibres arranged side by side and held in place by the intercellular substance above referred to (Plate 1, Fig. 6). The individual fibres (Plate 1, Fig. 7) are exceedingly long and slender, gradually tapering to a point at each end and presenting a more or less oval form in cross section. They are entirely devoid of markings, the surface appearing smooth and unwrinkled, and the protoplasm non-granular. But what is most remarkable is the fact that they are more or less hollow (Plate 1, Fig. 9), a character which, as we shall see later on, is common to nearly all the muscular fibres of the body. There can be no doubt as to this character since cross sections of the fibres show their hollow centers, which, in some instances, amounts to a large space and gives the sections the appearance of a ring, while in many cases it is small and not distinctly seen. The sections of fibres were examined with the new apochromatic objectives and compensating eye-pieces made by Carl Zeiss, and left no doubt as regards their being hollow.

In no case did I find the dermo-muscular fibres branch or anastomose. Although in a great many cases they appear to do so, nevertheless, upon close and rigid examination under high powers of the microscope, they were found to be nothing more or less than two or more fibres closely applied to one another and so arranged as to give the appearance of branching and anastomosing fibres (Plate 1, Fig. 6 d). Generally the tapering ends of one fibre are applied closely to the body of a neighboring fibre, where they adhere for a greater or less distance (Plate 1, Fig. 6 a). The ends of a fibre may, however, be joined to any part of another fibre, or one fibre may be applied to another so as to leave one or even both of its ends free for a considerable distance (Plate 1, Fig. 6 b, c). It will thus be seen that there is no definite and fixed mode or place of attachment, the fibres applying themselves to one another wherever convenient. They are not crowded together so as to form a dense layer, neither are they grouped together into fasciculi; but, on the contrary, form a loose layer, the individual fibres of which are separated from one another by a distance which is, in general, greater than the width of the fibre.

Thus far the description will apply to each muscular coat. But they differ, however, from one another, not only in the direction of the fibres, but also in a few minor characters, which it will be well to consider. The fibres of the first, or external and transverse coat (Plate 1, Fig. 5 a; Fig. 9 d) are $5\frac{1}{2}\mu$ wide and may vary in length from 1 mm. to $1\frac{1}{2}$ mm. They extend parallel to one another at a distance of from one and a half to twice the width of the fibre. Those of the second, or first longitudinal layer (Plate 1, Fig. 5 b; Fig. 9 e.) are much smaller than the fibres of any of the other layers, being only about one-half as wide as those of the first coat, although nearly as long, and usually lying a little farther apart. The fibres of the third, fourth, and fifth coats (Plate 1, Figs. 5 c, d, e; Figs. 9 f, g, h) are alike, except in their direction. They are larger than those of either the first or second layers, ranging from $8\frac{1}{2}\mu$ to $10\frac{1}{2}\mu$ in width, but of about the same length as the fibres of the other coats. They are separated from one another by scarcely the width of the fibre.

It will thus be seen from what has been said, that if we measure the distance from the center of one fiber to the center of the next, that this distance will practically be the same for the five coats, the difference in the separation of the fibres of the various coats being due to the difference in the width of the fibres in the one as compared with those in the other coats.

It was stated that the tegument contained five distinct muscular coats, each of which had fibres running in a certain direction; there is, however, an exception to this arrangement in the caudal part of the animal (Plate 1, Fig. 10). In the dorsal tegument, beginning just caudad of the ventral sucker (Plate 1, Fig. 10 f), we find the first muscular coat (Plate 1, Fig. 10 a) disappearing, and the second (Plate 1, Fig. 10 b) continuing to the caudal extremity as the most external layer. The third and fourth coats (Plate 1, Fig. 10 c) extend to the caudal extremity, where they become thin and disappear at the extreme end.

At about the place where the first layer disappears, we find the fifth coat (Plate 1, Fig. 10 d) cutting through the third and fourth (Plate 1, Fig. 10 c) and gradually taking a dorsal direction, at the same time becoming thinner, until it has reached the ectal surface of the third layer and there disappears. The third and fourth coats (Plate 1, Fig. 10 c) begin to thicken at the place where the fifth layer (Plate 1, Fig. 10 d) penetrates them and cease to be single layers of fibres, but are composed of two or more layers, the fibres of which are not arranged in regular order so as to be separated into a definite number of layers.

The Inner Matrix.—Finally, below the dermo-muscular coats, we find the fourth and last layer of the tegument (Plate 1, Fig. 9 i, Fig. 10 g; Plate 2, Fig. 2 e; Plate 3, Fig. 3 h). It consists of large oval cells, irregularly arranged, varying in diameter from 7μ to 17μ, with thin walls, granular protoplasm, and a large oval or spherical nucleus equally granular (Plate 1, Fig. 9 j k; Plate 3, Fig. 3 h). They are crowded quite closely together, and form a comparatively thick coat, the individual cells of which are cemented to one another and to the muscular coat by the intercellular substance. This inner matrix is traversed by a network of small canals (Plate 1, Fig. 9 l; Fig. 10 i; Plate 3, Fig. 3 b), or lacunæ, which will be considered later under the excretory system.

The Ventral Sucker.—The ventral sucker (Plate 1, Figs. 3, 4 f; Plate 2, Fig. 1 j; Fig. 3 t; Plate 3, Fig. 4) is hemispherical in form and is composed of three systems of muscles, surrounded by a membrane (Plate 3, Fig. 4 a) of fibrous tissue to which they are attached, and which separates them from the parenchyma. The muscular fibres have the form of a long spindle (Plate 3, Fig. 4 d), that tapers quite rapidly at both extremities, where they become fastened or united with the enveloping layer of fibrous tissue by a short, nearly transparent band of what is at first sarcolemma, but which merges insensibly into fibrous tissue. They have a perfectly smooth surface, are hollow, do not appear to be granulated, and never branch or anastomose. Both ends of the fibres are attached to the membrane surrounding the sucker, and in no case do they apply themselves to and terminate on another muscular fibre, but continue as one fibre to the end of their course. The fibres are all united and joined together by a connective tissue in which is found a number of large, granular, oval cells, with a distinct nucleus and nucleolus.

As regards the three systems of muscles, we have: First, on the ventral surface of the sucker, a single layer of small fibres, (Plate 3, Fig. 4 c) which run in circles, forming concentric rings just within the thin external layer of fibrous tissue; second, a single layer of thick fibres (Plate 3, Fig. 4 b) extending entad (equatorial), and forming a wide lateral band around the sucker; third, a system of large fibres (Plate 3, Fig. 4 d) forming the bulk of the sucker, they extend in a radiating manner from the ventral surface entad to the lateral and dorsal surface. They are from 14μ to 17μ in thickness, and by their contraction the floor of the sucker is raised.

The Parenchyma.

The parenchyma, as stated, forms the great bulk of the animal (Plate 1, Fig. 10; Plate 2, Figs. 1, 3, 4, 5). It is composed of a connective tissue (Plate 1, Fig. 10 j; Plate 2, Fig. 1 q; Fig. 2 j; Figs. 3, 4 n), in which are a number of large transparent polyhedral cells, with oval excentric nuclei, and a great amount of viscous and reticulated intercellular substance which cements together the cells and also the muscular fibres (Plate 1, Fig. 9 m; Fig. 10 e; Fig. 11 a; Plate 2, Fig. 1 o; Fig. 2 f; Fig. 3 m; Fig. 4 m; Fig. 5 a), which traverse the parenchyma in great numbers.

These muscular fibres are grouped together to form small fasciculi (Plate 1, Fig. 9 m; Fig. 11 a; Plate 2, Fig. 2 f) of from two to nine fibres, each of which extend in a dorso-ventral direction with more or less obliquity (Plate 1, Figs. 9, 10; Plate 2, Figs. 1. 4, 5) and connect the tegument on the ventral surface with that on the dorsal. They are known as the *dorso-ventral muscles.* The individual fibres are from 8½ μ to 17½ μ in diameter, and always, without exception, extend the entire length of the fascicle, in no case terminating at a point in it. It will thus be seen that the muscular fibres of the parenchyma, like those of the ventral sucker, never terminate on one another as do those of the tegument.

In either a transverse (Plate 2, Figs. 4, 5) or a sagittal (Plate 1, Fig. 10; Plate 2, Fig. 1) section of the body, the muscles (Plate 1, Fig. 10 e; Plate 2, Figs. 10, 4 m, 5 a) appear as bands extending obliquely or perpendicularly from the ventral to the dorsal tegument, while in a longitudinal section at right angles to the meson (Plate 2, Fig. 3) they are seen in cross section (Plate 1, Fig. 11 a; Plate 2, Fig. 2 f; Fig. 3 m). It is a remarkable fact that here also the fibres are seen to be more or less hollow. The individual fibres, although they resemble those in the tegument and ventral sucker, in that they are smooth, non-striated, and non-granular, and more or less hollow, nevertheless, differ greatly from all the other fibres in the animal, in that they divide and subdivide, not at one extremity only, but at both extremities (Plate 1, Fig. 9 m; Fig. 10 e). The fibres constituting a fasciculum separate from one another just before or immediately upon reaching the inner or second matrix of the tegument (Plate 1, Fig. 9); each fibre very soon divides, and the divisions then divide and subdivide, penetrate the dermo-muscular layers, and loose themselves in the first or external muscular layer and matrix.

The soft, spongy appearance of the parenchyma is due to its being full of irregular shaped cavities (Plate 1, Fig. 9 l; Fig. 10 k; Plate 2, Figs. 1 w, 2 k, 3 k, 5 b) which communicate with one another and with the canals in the inner matrix, forming a network of channels and chambers. These are known as the *lacunae*, and are supposed by Fairpont to represent the first appearance of a true cœlom.

The Excretory System.

In order to have made a complete study of the excretory system, fresh worms should have been obtained and this system of canals injected with some suitable material. Had that been possible, the complete course and ramifications of all the tubes could have been studied; but since hardened specimens were the only ones to be had, the terminations of the smaller branches (Plate 3, Fig. 3 c) and the large terminal vesicle (Plate 1, Fig. 3 g; Plate 2, Fig. 1 l, k) could alone be studied. Sections of the inner or second matrix of the tegument parallel to the surface (Plate 3, Fig. 3) formed the principal source for the study of the terminations of the excretory canals.

The inner matrix (Plate 1, Fig. 9 i; Fig. 10 g) of the tegument is, as stated, traversed by a network of tunnels or lacunae (Plate 1, Fig. 9 l; Fig. 10 i; Plate 3, Fig. 3 b); in these tunnels run the tubes of the excretory system (Plate 3, Fig. 3 c), and it is here that by far the greater part of them terminate, the remainder terminating along the alimentary canal and in the lacunae of the general parenchyma.

The tubes of the excretory system not only divide and subdivide, but the branches anastomose (Plate 3, Fig. 3) and thus form a complete network of vessels. They have thin, smooth, transparent walls (Plate 3, Fig. 3 c) which are without structure, except that they have scattered through them small oval nuclei (Plate 3, Fig. 3 e) which are probably the nuclei of the cells out of which the tubes were originally formed, but which now constitute the only indication of their cellular origin, the adjoining walls of the cells having disappeared. The canals were found to terminate without exception in closed rounded ends (Plate 3, Fig. 3 d). Not a trace of a funnel-shaped opening or even an opening of any kind was to be seen. The lacunae are larger than the excretory canals, so that there is left a considerable space around the tubes (Plate 3, Fig. 3 b). The branches unite to form larger branches, until they finally empty into a common vessel or reservoir (Plate 2, Fig. 1 l) of an irregular oval form, situated on the dorsal aspect at about two-thirds the length of the animal from the mouth. This common receptacle is called the *terminal vesicle* and opens on the exterior by a small aperture known as the *caudal foramen* or *excretory pore* (Plate 2, Fig. 1 k).

The Alimentary Canal.

The alimentary canal is divided into five distinct regions, all of which are sharply defined. They are, commencing with the most cephalic: First, the pharynx (Plate 1, Figs. 3, 4 b; Plate 2, Figs. 1, 3 b), which is divided into a true pharynx and a buccal cavity; second, the pharyngeal bulb (Plate 2, Figs. 1, 3 d); third, the oesophagus (Plate 1, Figs. 3, 4 c; Plate 2, Figs. 1, 3 f); fourth, the muscular crop (Plate 2, Figs. 1, 3 g); and fifth, the caeca (Plate 1, Figs. 3, 4 e; Plate 2, Fig. 3 s).

The Pharynx.—The mouth is circular and opens into a funnel-shaped cavity (Plate 2, Figs. 1, 3 a), the buccal cavity, which leads into the exceedingly long and straight pharynx (Plate 2, Figs. 1, 3 b). The separation of the fore part of the pharynx into mouth and buccal cavity is not a distinct one. The pharynx is nothing but an invagination of the body-wall or tegument, with a slight change in the dermo-muscles after entering the pharynx proper. The cuticle (Plate 2, Fig. 2 a) gradually thins out and disappears in the buccal cavity; the first or transverse layer of dermo-muscular fibres (Plate 2, Fig. 2 b), however, increase in diameter and continue down the pharynx as annular or circular fibres, running around it and constituting its second layer (Plate 2, Fig. 2 h), while the fibres of the second, third, fourth and fifth dermo-muscular coats (Plate 2, Fig. 2 c d) gradually assume a common direction and extend down the pharynx as a thick layer of longitudinal muscular fibres, forming the third or longitudinal muscular layer of the pharynx (Plate 2, Fig. 2 i). The outer matrix of the tegument extends down the pharynx as its first or lining membrane (Plate 2, Fig. 2 g), while the inner matrix of the tegument continues down the pharynx as its fourth or external layer of tissue (Plate 2, Fig. 2 e). The muscular fibres and the different layers of the pharynx are held together by a continuation of the same intercellular substance as is found in the tegument.

The Pharyngeal Bulb.—The pharynx leads into a muscular, thick-walled chamber (Plate 2, Figs. 1, 3 d; Plate 3, Fig. 1), the pharyngeal bulb, which is not a mere swelling of the walls of the pharynx, but, on the contrary, is a distinct organ of a somewhat oval form, the muscular fibres of which have certain directions independent of those of the pharynx. Although the muscular fibres in the pharyngeal bulb are not grouped together into distinct and easily-definable layers, but are more or less crowded and woven together, nevertheless, five systems of fibres are to be recognized. The two most important systems and the ones which constitute the bulk of the bulb are: First, radial muscular fibres (Plate 3, Fig. 1 e); these extend from the interior or inner lining membrane

(Plate 3, Fig. 1 b) in a radiating manner to the exterior or outer membrane (Plate 3, Fig. 1 h), which is of a fibrous nature and surrounds the bulb the same as the fibrous membrane around the ventral sucker, and, like it, forms a place for the attachment of the muscles; second, fibres (Plate 3, Fig. 1 g) which extend between those of the radial and perpendicular to them, they encircle the bulb in a cephalo-caudal direction and are seen in cross section in a transverse section of the bulb. A single row of muscular fibres (Plate 3, Fig. 1 c) having the same direction as those of the last system, but with a much greater diameter, form the most external layer of the muscles of the pharyngeal bulb. Just within this outer encircling layer is another layer (Plate 3, Fig. 1 d) of several fibres in thickness, which encircle the bulb in the direction at right angles to the last-named layer, and which appear as hoops in a transverse section of the bulb. About midway between the exterior and interior surfaces of the bulb is another similar layer (Plate 3, Fig. 1 f).

The cavity (Plate 3, Fig. 1 a) of the pharyngeal bulb is sub-oval, with two lateral chambers (Plate 2, Fig. 3 d; Fig. 4 c) in the caudal region dorsad of the opening into the oesophagus. The opening into the pharynx, and, to a certain extent, the one into the oesophagus, is capable of being closed by the contraction of the muscles surrounding it. By the contraction and expansion of its muscular walls, together with the closing and opening of the aperture leading into the pharynx, the pharyngeal bulb forms a powerful organ of suction, by means of which the food material is drawn into its interior and forced through the oesophagus into the muscular crop.

Attached around the caudal part of the lateral margin of the bulb are several groups of muscular fasciculi (Plate 2, Figs. 1, 3, 4 e), which extend caudad, and in a radiating manner to the body-wall or tegument to which they are fastened. The ends towards the pharyngeal bulb are attached to the fibrous tissue surrounding it in the same manner as the fibres of the ventral sucker are attached to their enclosing membrane, but the ends which are fastened to the tegument divide and subdivide, and weave themselves among the dermo-muscular fibre, becoming lost in them the same as the dorso-ventral muscles of the parenchyma. These are the retractor muscles of the pharynx. They serve to draw in the pharynx, which is capable of being protuded or evaginated as a probosis, and which, in many specimens that have been killed, is thus seen to be extended. The protrusion is mainly due to the general contraction of the muscles of the tegument, which compress the interior so as to cause the pharynx to be pushed out and evaginated.

The Œsophagus.—The pharyngeal bulb opens at its ventro-caudal aspect into a tube (Plate 2, Figs. 1, 3 f), the œsophagus, which is of about the same length as the pharynx, but has a greater diameter, and in its normal state is curved so as to have the appearance of the figure three (3). The œsophagus, like the pharynx, has: First, its inner lining membrane, which is not to be structurally distinguished from the intercellular substance; second, an annular or circular layer of muscular fibres flattened in the direction of the tube and extending around it; third, a longitudinal layer, the fibres of which run lengthwise; and fourth, an external layer of cells similar to those of the inner matrix of the tegument, and held together by the intercellular substance, which unites insensibly with the connective tissue of the parenchyma.

The Crop.—The œsophagus communicates directly with the so-called crop (Plate 2, Figs. 1, 3 g; Plate 3, Fig. 2) by an aperture in the ventral aspect of the latter. The crop is not a mere expanded portion of the œsophagus, as the name would suggest, but, like the pharyngeal bulb, is a distinct organ of itself, composed of a muscular thick-walled sac. In form it (Plate 1, Figs. 1, 3 g; Plate 3, Fig. 2) is not unlike a pear, with the more pointed end ventrad, at which place it joins the œesophagus, communicating with it by a constricted opening (Plate 3, Fig. 2 d) which leads into the flask-shaped cavity (Plate 3, Fig. 2 a, g) of the crop, the neck of which is also in a ventral position. The wall of the crop (Plate 3, Fig. 2) is very thick, and, like the preceding divisions of the alimentary canal, is lined with and surrounded by a continuation of the same membranes (Plate 3, Figs. 2 h, k) that line and surround the alimentary canal thus far described. The muscular layers are, however, very different from those in the other portions of the alimentary tract. The arrangement of the fibres of the muscular wall may perhaps be more easily understood if we begin with the middle layer (Plate 3, Fig. 2 c, e, f). It consists of a great many annular fibres, grouped together to form a ring (Plate 3, Fig. 2 c), which encircles the ventral aspect of the crop at its junction with the œsophagus, and another similar ring of annular fibres (Plate 3, Fig. 2 f), having the same direction and running around the expanded part of the crop, near its dorsal aspect. Between these two rings are fibres running in a radial direction (Plate 3, Fig. 2 e) which, however, as they near the rings, gradually take upon themselves the annular direction and pass insensibly into the latter. Both on the ectal and ental surface of this middle layer just described, is a muscular coat (Plate 3, Fig. 2 m, b), the fibres of which extend from the ventral to the dorsal ring, over which they unite to form a thick layer (Plate 3, Fig. 2 n) constituting the dorsal wall of the crop. The muscular ring (Plate 3, Fig. 2 c) surrounding the opening which leads from the crop into the œsophagus is, by its contraction, able to close the opening (Plate 3, Fig. 2 d). The food is, as stated, forced through the œsophagus into the crop by the action of the pharyngeal bulb. By the contraction of the crop the food is then forced through two openings (Plate 2, Fig. 3; Fig. 5 s) ,situated in the dorso caudal part of the lateral walls, and which communicates directly with the two caeca now to be described.

The Caeca.—The caeca (Plate 1, Fig. 3, 4, e; Plate 2, Fig. 3, s) are the true organs of digestion, they alone fulfilling the office of both stomach and intestine. They originate at the crop, from which they immediately diverge (Plate 1, Fig. 4, e ; Plate 2, Fig. 3, s), one passing down each side of the body to about opposite the ventral sucker, where they terminate in rounded and closed ends. They are long, thin, walled cylinders, with a greater diameter, and with a structure which is also quite different from that of the other portions of the alimentary canal.

The smooth non-folded inner lining membrane (Plate 1, Fig. 11, g; Fig. 12) or mucosa of the caeca is composed of a single layer of columnar, hexagonal cells crowded closely together, with thin walls (Plate 1, Figs. 11, 12, c), granular contents (Plate 1, Figs. 11, 12, b), and a large rounded and glanular nucleus (Plate 1, Fig. 11, h; Fig. 12, a). The layer of annular muscular fibers, which forms the next coat (Plate 1, Fig. 11, f) of the caeca, is remarkable as being the only layer or system of muscles in the entire animal which are not composed of hollow fibers. Still another peculiarity is to be found in the manner in which they terminate. The fibers are, like all the other muscular fibers of the animal, perfectly devoid of markings or wrinkles of any kind. They are oval in cross section and the two ends taper very suddenly to a point. Each fiber extends once around the caecal tube, commencing on its dorsal surface, along which the termination of all the fibers take place, and form a straight line, the ends overlapping for only a very short distance, which is scarcely equal to the bevel of the termination (Plate 1, Fig. 8 c).

The second or outer muscular coat (Plate 1, Fig. 11 e) is very different from the first. Not only do the fibers run lengthwise of the caeca, or at right angles to those of the first layer, but they are only about one-sixth as great in diameter, although severel times as long, while the distance between them is very much greater (Plate 1, Fig. 8 b). The difference in the distance between the fibers of the one as compared to those of the other layer is due to the difference in the diameter of the fibers of the two layers (Plate 1, Fig. 8).

Surrounding the second muscular coat is a thick layer of granular substance (Plate 1, Fig. 11 b), without structure, but of the nature of connective tissue, and in which is found, scattered irregularly through it, large oval cells (Plate 1, Fig. 11 c), with granular contents containing a large granular nucleus (Plate 1, Fig. 11 d). This outer layer merges insensibly into the intercellular substance which cements the muscular fibers and the different layers of the caeca together, and also into the fibrous connective tissue of the parenchyma.

The Nervous System.

The nervous system was not well made out in the sections, as they were prepared with no special reference to the nerves. The nervous center is all that we will allude to. It is very prominent in both sagittal and longitudinal sections at right angles to the meson, and here appears as a finely granular mass surrounding the pharynx and extending from the pharyngeal bulb to beyond the middle of the pharynx (Plate 2, Figs. 1, 3 c). The nervous mass is enlarged on either side of the pharynx so as to constitute two latteral ganglia (Plate 2, Fig. 3 c) of a wedge-shape form, the point being cephalad. I have been unable to trace any nerves given off by these two ganglia, save the ones which run around the pharynx and connect the two ganglia by a ventral and dorsal commissure.

The Reproductive System.

The reproductive system was not studied in detail, owing to the material. It may be well to state, however, that the male and female organs open on the exterior by a common pore (Plate 2, Figs. 1, 5 h), and that cross fertilization could be possible only when the two organs reach maturity at different periods.

Explanation of Plates.

Plate I.

Fig. 1. Dorsal view of Amphistomum fabaceum, nat. size.

Fig. 2. Lateral view of A. fabaceum, nat. size.

Fig. 3. Lateral view, × 3 diam.

Fig. 4. Dorsal view, × 3 diam.

a, mouth; *b*, pharynx and bulb; *c*, oesophagus and crop; *d*, opening of reproductive organs; *e*, caeca; *f*, ventral sucker; *g*, excretory pore.

Fig. 5. Diagram to illustrate the different muscular layers of the dermis or tegument and their respective relations and directions.

a, the first dermo-muscular layer; *b*, the second; *c*, the third; *d*, the fourth; *e*, the fifth or inner layer.

Fig. 6. A portion of the fifth dermo-muscular layer as seen in a surface view, the fibres having their natural position, × 250 diam.

a, *b*, *c*, *d*, different modes of attachment of the fibres to one another.

Fig. 7. A dermo-muscular fibre isolated, × 250 diam.

Fig. 8. A portion of the muscular coats of the caeca from the dorsal wall, as seen in a surface view, the fibre having their natural position, × 280 diam.

a, inner or annular layer; *b*, the outer or longitudinal layer; *c*, the termination of the fibres.

Fig. 9. Portion of a sagittal section of the dorsal tegument, × 280 diam.

a, spines of the cuticle; *b*, the cuticle; *c*, the matrix; *d*, the first or outer dermo-muscular layer; *e*, the second dermo-muscular layer; *f*. the third dermo-muscular layer; *g*, the fourth dermo-muscular layer; *h*, the fifth dermo-muscular layer; *i*, the inner matrix; *j*, cells of the inner matrix; *k*, nuclei of the cells; *l*, lacunae; *m*, dorso-ventral muscles.

Fig. 10. A sagittal section of the caudal part of the animal, × 95 diam.

s, the cuticle; *a*, first dermo-muscular layer; *b*, second dermo-muscular layer; *c*, third and fourth dermo-muscular layers; *d*, fifth dermo-muscular layer; *e*, dorso-ventral muscles; *f*, ventral sucker; *g*, inner matrix; *h*, inner matrix thickened at the caudal extremity; *i*, lacunae; *j*, connective tissue; *k*, lacunae.

Fig. 11. Longitudinal section of the wall of a caecum, × 280 diam.

a, fasciculi seen in transverse section and showing the hollow fibres of which they are composed; *b*, outer or external coat of the caeca; *c*, large cells scattered through it; *d*, nucleus; *e*, outer or longitudinal layer of muscles; *f*, inner or annular layer of muscles; *g*, mucosa; *h*, nuclei of the cells of the mucosa.

Fig. 12. Surface view of the mucosa of the caeca, × 560 diam,

a, nucleus; *b*, cell body; *c*, cell wall.

Plate II.

Fig. 1. Sagittal section of Amphistomum fabaceum, × 15 diam.

a, mouth and buccal cavity; *b*, pharynx; *c*, nervous ganglia or rather commissure; *d*, pharyngeal bulb; *e*, retractor muscles of the pharynx; *f*, oesophagus; *g*, crop; *h*, opening of the reproductive organs; *i*, ovaries; *j*, ventral sucker: *k*, excretory pore; *l*, common vessicle or reservoir to the excretory system; *m*, oviduct and vas deferens; *n*, muscular wall of the pharyngeal bulb; *o*, dorso-ventral muscles; *p*, muscular wall of the crop; *q*, connective tissue of the parenchyma; *s*, buccal sucker; *v*, tegument; *w*, lacunae of the parenchyma.

Fig. 2. Longitudinal section of the wall of the pharynx, buccal cavity, mouth and tegument, to show the changes which the dermo-muscular layers undergo as they enter the alimentary canal to constitute its muscular coats, × 150 diam.

a, cuticle; *b*, first or outer layer of muscles of the tegument; *c*, third and fourth muscular layers of the tegument; *d*, fifth muscular layer of the tegument; *e*, inner matrix; *f*, fasciculi; *g*, first or inner layer of the pharynx; *h*, second, or first, muscular layer of the pharynx; *i*, third, or second, muscular layer of the pharynx; *j*, connective tissue of the parenchyma; *k*, lacunae.

Fig. 3. Longitudinal section of A. fabaceum at right angles to the meson. The alimentary canal, especially the oesophagus, was constructed from a series of sections, × 15 diam.

a, mouth and buccal cavity; *b*, pharynx; *c*, nervous ganglia; *d*, pharyngeal bulb; *e*, retractor muscles of the pharynx; *f*, oesophagus; *g*, crop; *k*, lacunae of the parenchyma; *m*, fasciculi; *n*, connective tissue of the parenchyma; *o*, tegument; *s*, caeca; *t*, ventral sucker.

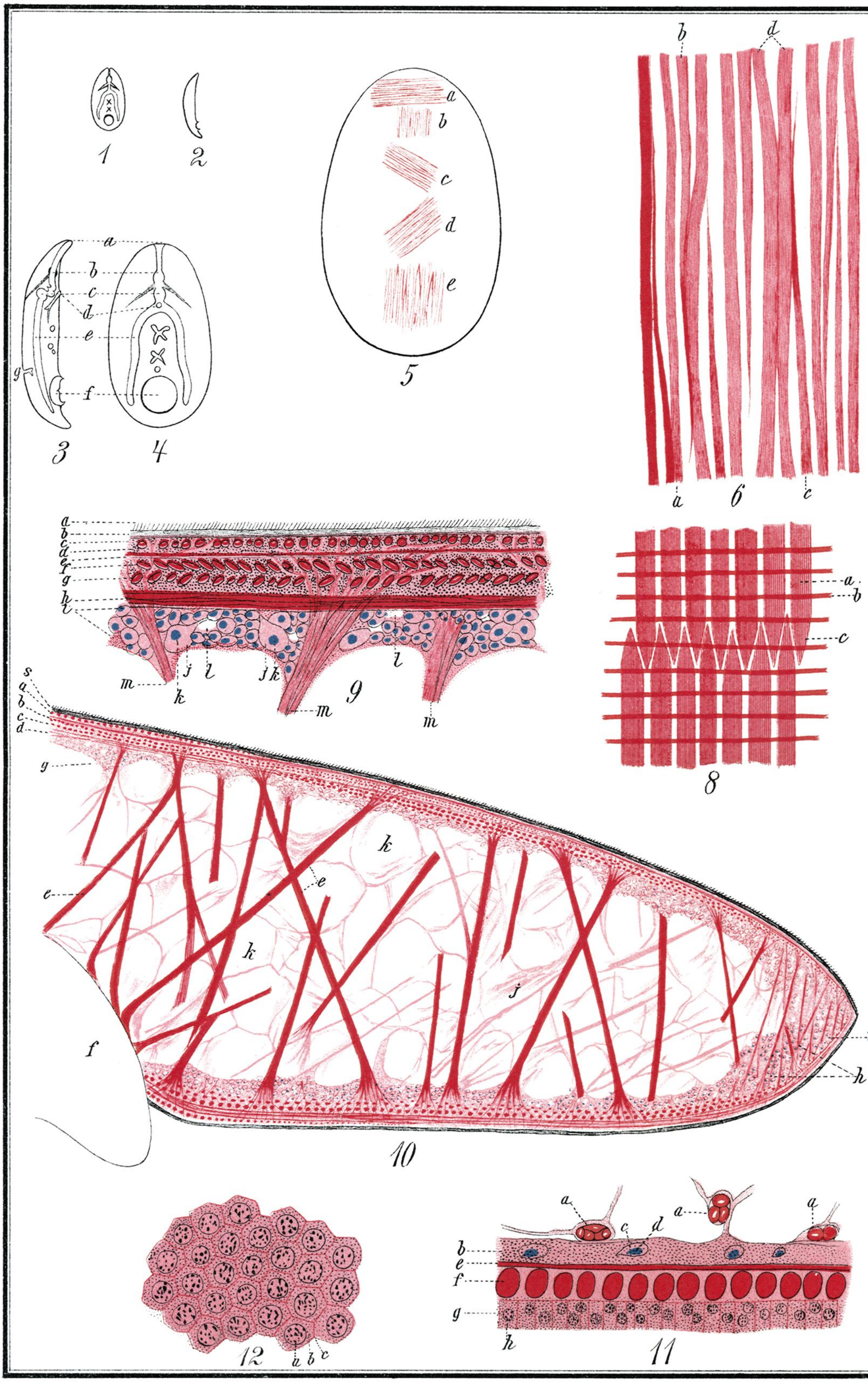

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PLATE I.—STEDMAN.

Plate I.

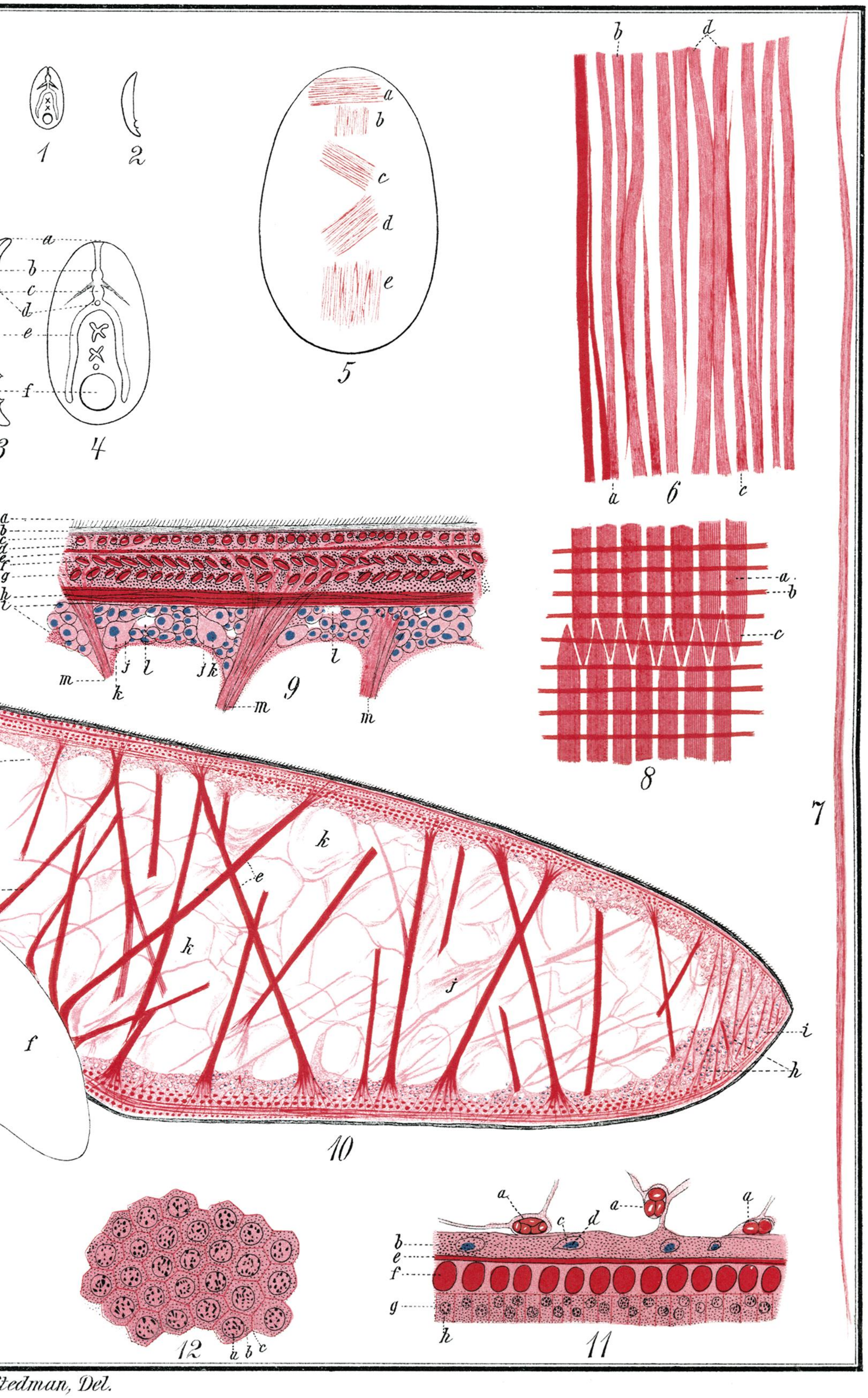

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PLATE I.—STEDMAN.

Plate II

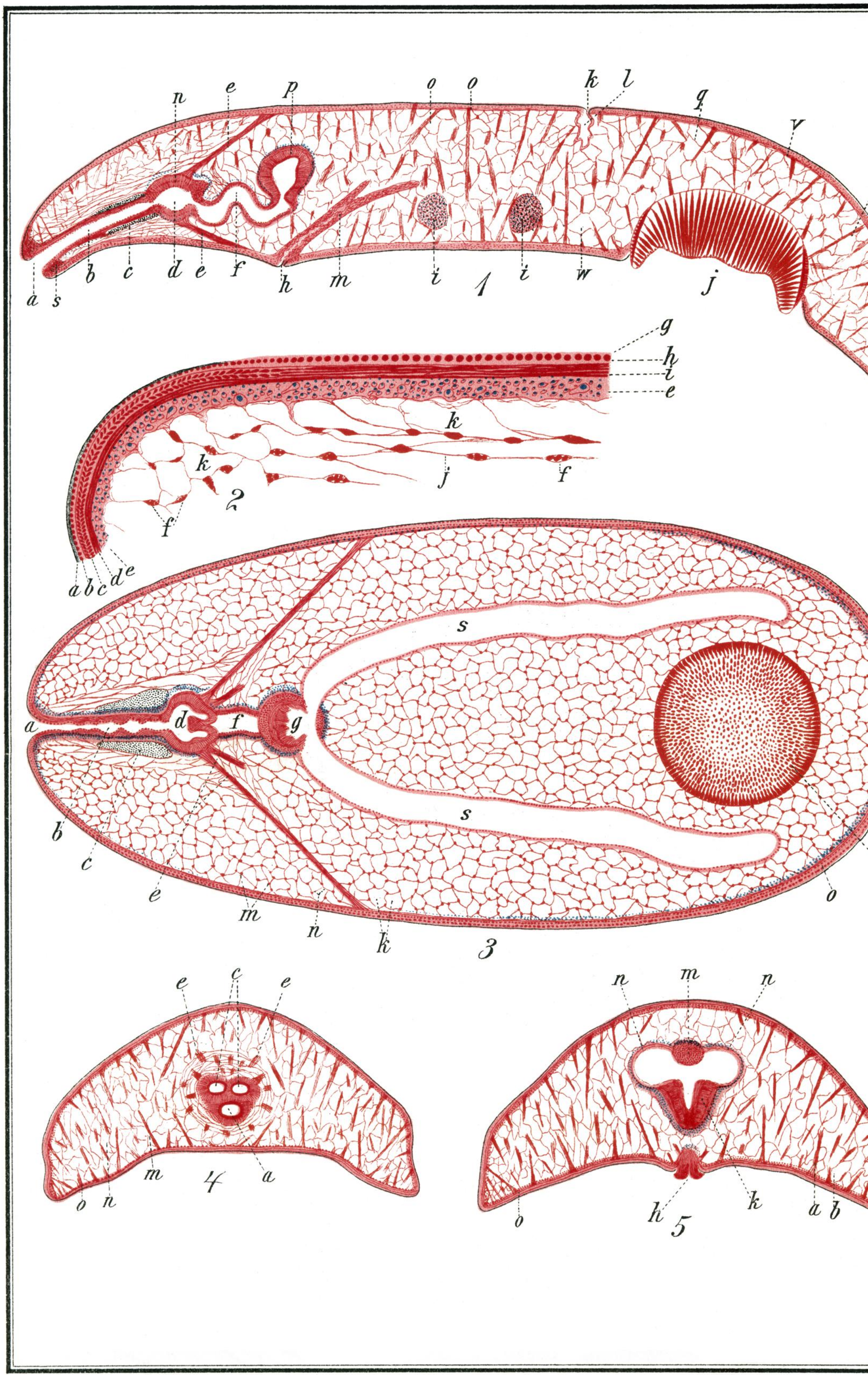

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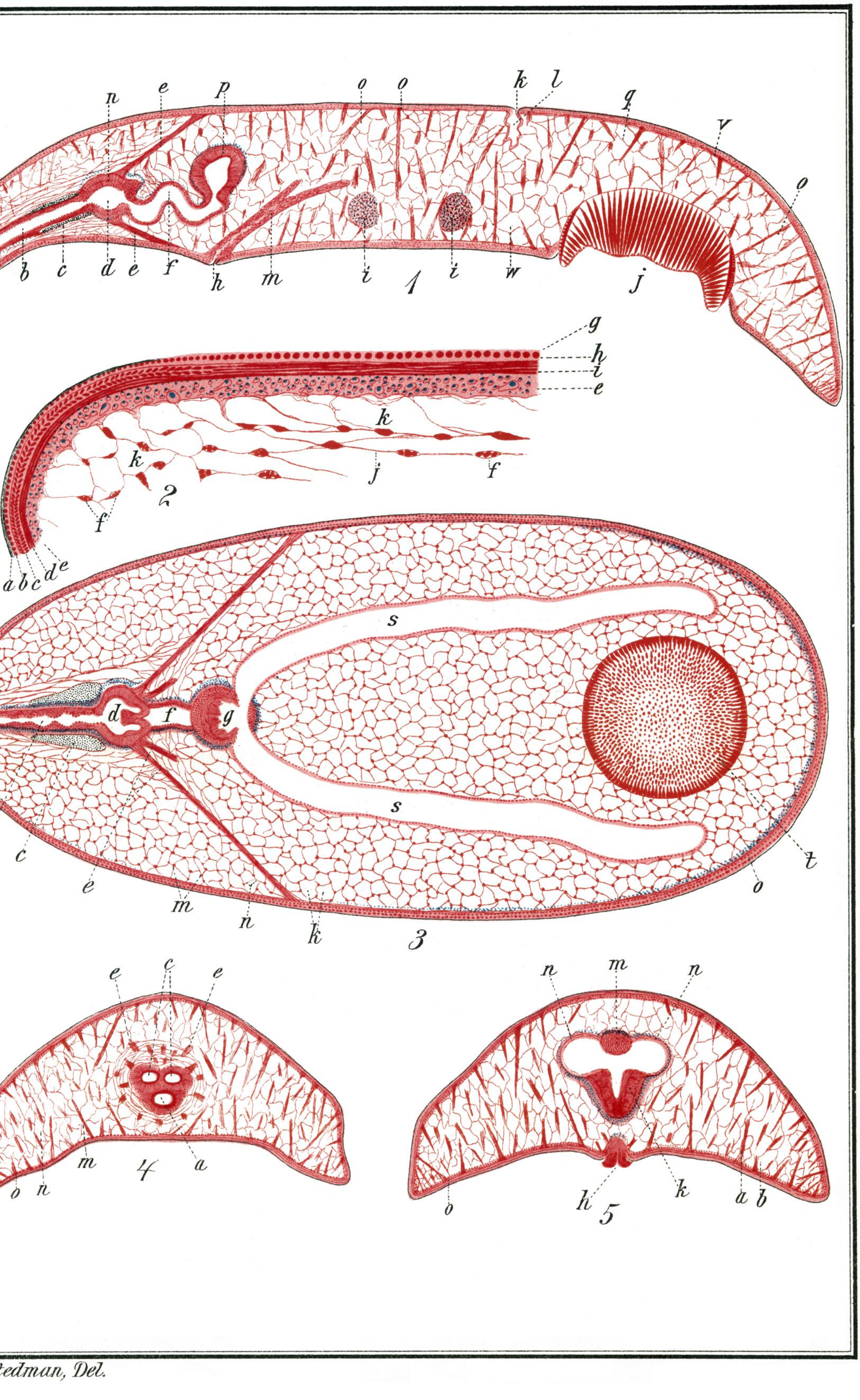
Plate II.



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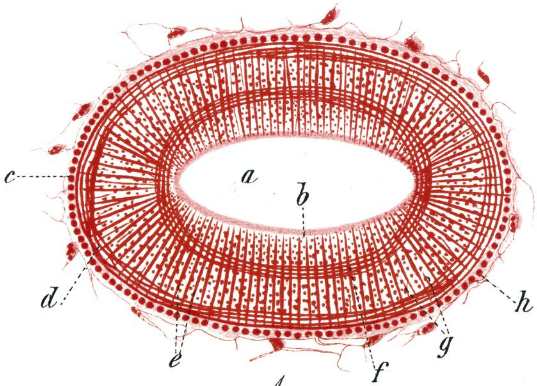

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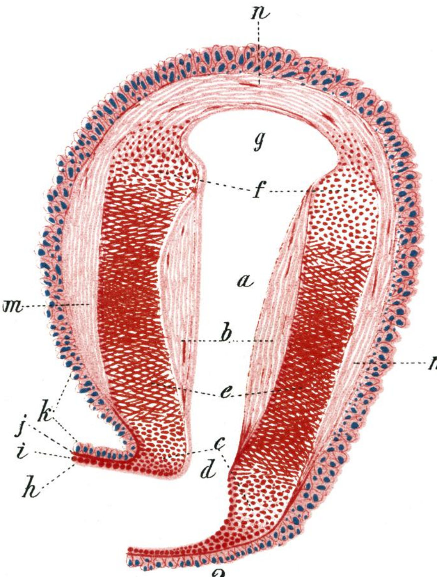

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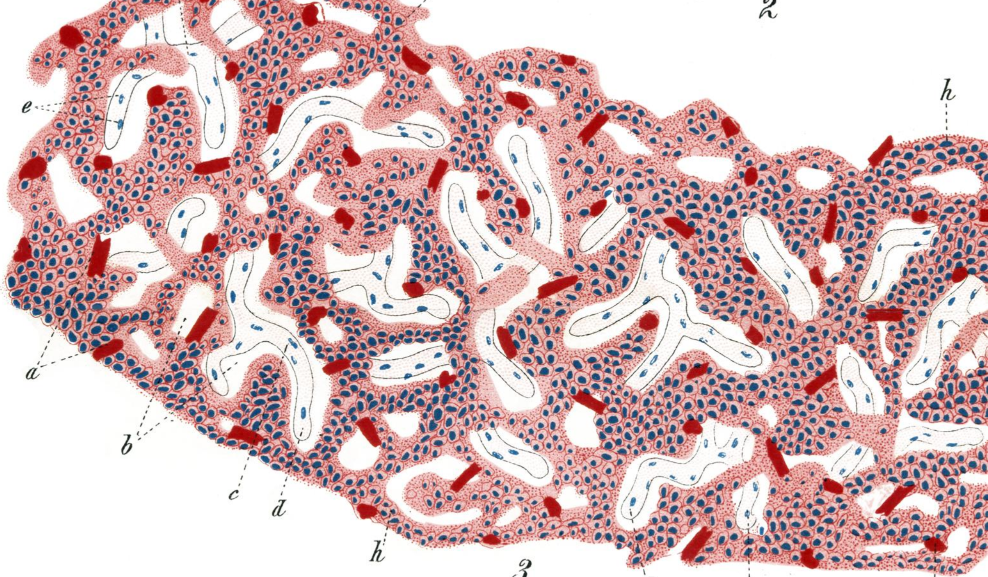

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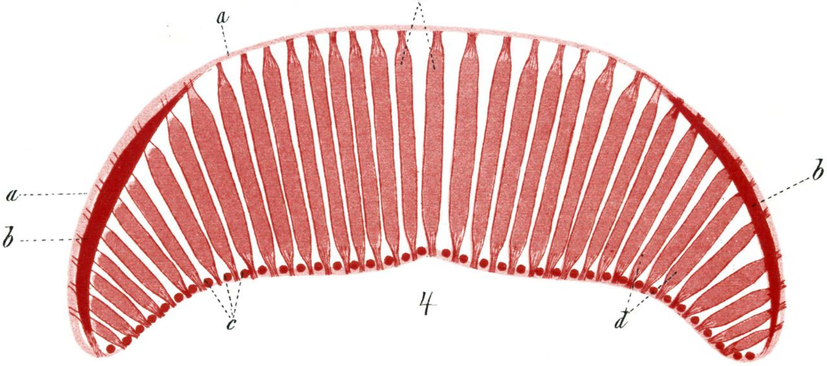

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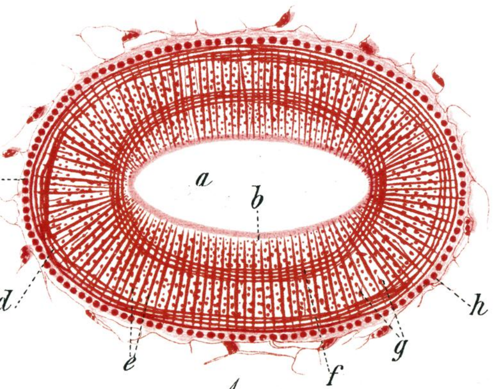
PLATE III.—STEDMAN.

Plate III.



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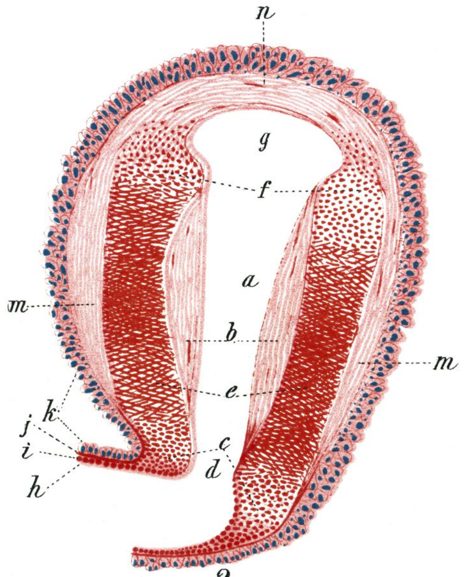

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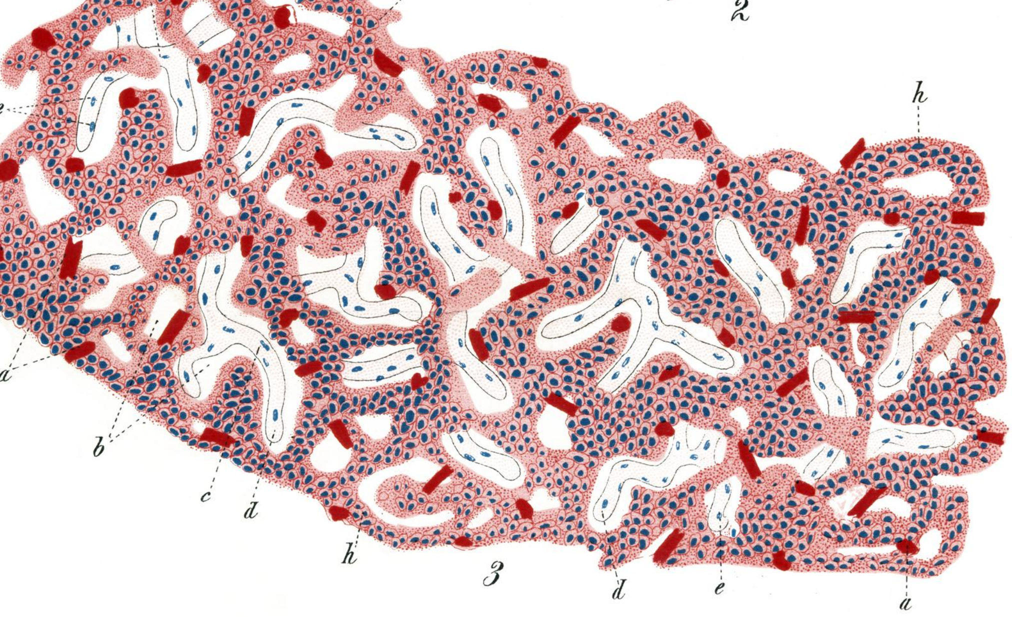

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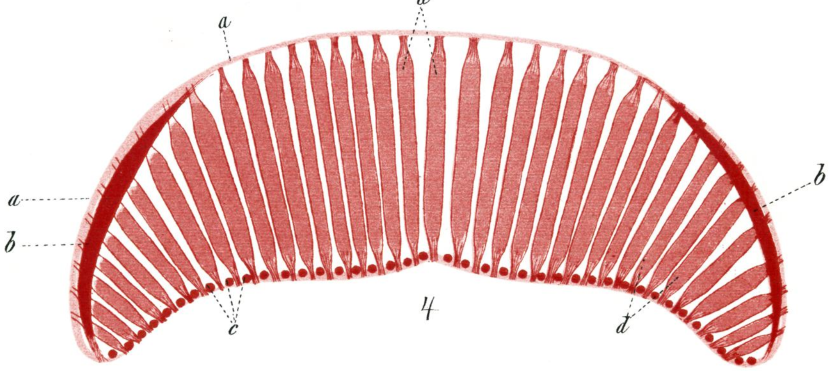

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PLATE III.—STEDMAN.

Fig. 4. Transection of A. fabaceum through the pharyngeal bulb, × 15 diam.
a, opening of the bulb into the oesophagus; *c*, the two lateral chambers of the bulb; *e*, the fasciculi of the muscles which retract the pharynx and which are attached to the bulb; *m*, fasciculi of the parenchyma; *n*, parenchyma; *o*, tegument.

Fig. 5. Transection of A. fabaceum through the crop and reproductive opening, × 15 diam.
a, fasciculi; *b*, lacunae of the parenchyma; *i*, cavity of the crop; *k*, muscular wall of the crop; *h*, opening of the reproductive system; *m*, dorsal wall of the crop; *n*, walls of the caeca where they join the crop; *o*, tegument; *s*, cavity of the caeca.

Plate III.

Fig. 1. Transection of the pharyngeal bulb, × 100 diam.
a, cavity of the bulb; *b*, inner or lining membrane; *c*, outer layer of muscular fibres; *d*, a layer of several muscular fibres deep, running at right angles to those of *a*; *e*, radical muscular fibres; *f*, an inner layer of muscular fibres, similar to those of *d*; *g*, muscular fibres running between the radial and at right angles to them; *h*, outer or encircling layer of fibrous tissue.

Fig. 2. Sagittal section of the crop, × 100 diam.
a, *g*, cavity of the crop; *b*, inner muscular layer; *c*, ring of muscular fibres running around the opening (d) into the oesophagus; *d*, the opening into the oesophagus; *e*, radial muscular fibres; *f*, ring of muscular fibres running around the expanded portion of the crop; *h*, inner, or lining membrane of the oesophagus, which also extends into and lines the crop; *i*, inner or annular layer of muscles of the oesophagus; *j*, outer or longitudinal muscular layer of the oesophagus; *k*, layer of cells forming the outer coat of the oesophagus and crop; *m*, outer muscular layer of the crop; *n*, muscular layer forming roof of the crop.

Fig. 3. Section of the inner matrix, parallel to the surface, × 300 diam.
a, fasciculi of the parenchyma cut across at various angles; *b*, lacunae of the matrix; *c*, canals of the excretory system; *d*, terminations of the canals; *e*, nuclei in the walls of the canals; *g*, anastomosing canals; *h*, cells of the matrix with their nuclei.

Fig. 4. Sagittal section of the ventral sucker. This is somewhat diagramatic for the sake of simplicity and clearness, × 55 diam.
a, outer or encircling membrane of fibrous tissue; *b*, equatorial muscular fibres; *c*, circular or annular muscular fibres forming concentric rings on the ventral surface and seen here in cross section; *d*, radial muscular fibres.

The striated appearance of some of the muscular fibers is due to the work of the lithographer, and should not be there.

CORNELL UNIVERSITY, Ithaca, N. Y., June, 1888.